ELECTROPHORETIC MEDIUM PROVIDED WITH SPACERS

REFERENCE TO RELATED APPLICATION

This application claims priority from Provisional Application Serial No. 60/142,003 filed Jul. 1, 1999.

FIELD OF THE INVENTION

The present invention relates to an electrophoretic medium provided with spacers, and to an electrophoretic display incorporating such a medium.

BACKGROUND OF THE INVENTION

Electrophoretic displays have been the subject of intense research and development for a number of years. Such displays can have attributes of good brightness and contrast, wide viewing angles, state bistability, and low power consumption when compared with liquid crystal displays. (The terms "bistable" and "bistability" are used herein in their conventional meaning in the art to refer to displays comprising display elements having first and second display states differing in at least one optical property, and such that after any given element has been driven, by means of an addressing pulse of finite duration, to assume either its first or second display state, after the addressing pulse has terminated, that state will persist for at least several times, for example at least four times, the minimum duration of the addressing pulse required to change the state of the display element.) Nevertheless, problems with the long-term image quality of these displays have prevented their widespread usage. For example, particles that make up electrophoretic displays tend to cluster and settle, resulting in inadequate service-life for these displays.

An encapsulated, electrophoretic display typically does not suffer from the clustering and settling failure mode of traditional electrophoretic devices and provides further advantages, such as the ability to print or coat the display on a wide variety of flexible and rigid substrates. (Use of the word "printing" is intended to include all forms of printing and coating, including, but without limitation: pre-metered coatings such as patch die coating, slot or extrusion coating, slide or cascade coating, curtain coating; roll coating such as knife over roll coating, forward and reverse roll coating; gravure coating; dip coating; spray coating; meniscus coating; spin coating; brush coating; air knife coating; silk screen printing processes; electrostatic printing processes; thermal printing processes; ink jet printing processes; and other similar techniques.) Thus, the resulting display can be flexible. Further, because the display medium can be printed (using a variety of methods), the display itself can be made inexpensively.

One major reason why encapsulated electrophoretic displays can be produced inexpensively by printing processes is that the electrophoretic medium itself has substantial mechanical strength and cohesion; typically the individual capsules are bound together by a polymeric binder to increase the cohesion of the layer. Thus, not only can the display medium itself be printed, but as described in copending application Ser. No. 09/141,103 and the corresponding International Application No. PCT/US98/17735 (Publication No. WO 99/10768), an electrode may be formed by printing a conductive material directly on to the electrophoretic medium; alternatively, an electrode preformed on a substrate can be laminated on to the electrophoretic medium, which is able to withstand the heat and pressure required for such lamination without damage. In such printed or laminated structures, the mechanical strength and cohesion of the electrophoretic medium maintain the requisite spacing between the electrodes disposed on either side of the medium without any need for mechanical spacers or similar devices to control this spacing. Accordingly, if the electrodes (and any substrates attached thereto) are flexible, the encapsulated electrophoretic display can be curved or rolled without affecting the display qualities of the device; see, for example, Drzaic et al., "A Printed and Rollable Bistable Electronic Display SID (Society for Information Display) 98 Digest, page 1131 (1998), which illustrates a flexible encapsulated electrophoretic display being rolled around a pencil without damage.

Although, as described above, encapsulated electrophoretic media possess considerable mechanical strength and cohesion, it is of course important that none of the capsules in such displays be ruptured, since rupture of even a small number of capsules allows the internal phase of the capsules (this internal phase comprising the electrophoretic particles themselves and the liquid medium in which they are suspended) to leak through the medium, thus adversely affecting the appearance of the display. It has now been found that, by providing spacers within such an encapsulated electrophoretic medium, the resistance of the medium to mechanical stresses can be increased, thereby enabling the medium to be used in applications, and under processing conditions, which would otherwise result in unacceptable capsule rupture.

SUMMARY OF THE INVENTION

In one aspect, this invention provides an encapsulated electrophoretic medium comprising a layer of capsules, each of these capsules comprising a liquid and at least one particle disposed within the liquid and capable of moving therethrough on application of an electric field to the medium. The medium also comprises a plurality of spacers dispersed among the capsules.

In another aspect, this invention provides a method of forming an electrophoretic display; this method comprises (a) providing a substrate; and (b) providing, adjacent the substrate, an encapsulated electrophoretic medium comprising a layer of capsules, each of these capsules comprising a liquid and at least one particle disposed within the liquid and capable of moving therethrough on application of an electric field to the medium. The medium also comprises a plurality of spacers dispersed among the capsules.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**, **2** and **3** of the accompanying drawings are schematic cross-sections, taken perpendicular to the plane of the electrodes of the displays, through three different preferred encapsulated electrophoretic displays of the present invention. These drawings are not to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

DETAILED DESCRIPTION OF THE INVENTION

As already mentioned, in the encapsulated electrophoretic medium of the present invention a plurality of spacers are dispersed among the capsules. These spacers serve to relieve some of the pressure which would otherwise be applied to the capsules when substantial pressures are placed upon the electrophoretic medium, thus enabling the medium to withstand, without capsule rupture, higher pressures than it would be able to withstand in the absence of the spacers.